What Does Design and Technology Learning Really Look Like?

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Abstract

This paper presents findings from a research study investigating the relationship between *intended* learning and *actual* learning in Design and Technology lessons (Southall, 2015). The research focused upon the 'pre active' phase of the teaching-learning process, that is the teacher's planning processes and procedures. The planning processes and procedures used by teachers are an essential pre-requisite to ensuring students' progress their learning and consequently a vital aspect of teaching. Unfortunately however, it is an area of teaching often only considered in the context of 'novice' teachers. With the recent increasing focuses on the production of measurable learning 'outputs' in education, understanding the mechanisms behind effective planning processes that provide appropriate learning experiences, producing a range of learning outcomes is challenging for teachers and schools.

The concept of being able to identify students' learning and consequently plan for, capture and then gather learning, is directly related to the notion of learning outcomes, however can learning outcomes demonstrate the type of learning required to progress in Design and Technology? The role and function of a learning outcome within the teaching-learning process, the influences on and issues involved in the application of Design and Technology learning outcomes will be discussed.

Seventy lesson plans were analysed and the intended learning outcome was identified and compared with the actual learning outcome produced during the lesson. The findings from this study reveal that the dominant, systematic planning model used by many teachers, provides only to a limited extent the relational framework for the *intended* and *actual* learning that supports the teaching-learning process. The prevailing focus on learning outcomes identified during this research is, it is argued, unable to fully support the multidimensionality and multimodality integral to Design and Technology learning. Instead it is restrictive and promotes a limited approach to the subject in relation to both teaching and learning. The study concludes that the planning processes and procedures in Design and Technology need to be developed with the clear intention of strengthening their role within the teaching-learning process. This would encourage the development of the underlying important principles inherent within the subject and support teachers' and students' achievement, creativity and enjoyment in teaching and learning in the classroom.

Key words

learning intentions, learning outcomes, classroom-based learning, evidence of learning, learning progress

Introduction

In 2007 I was asked to work on the Qualification and Curriculum Authority's (QCA) *National Exemplification of Standards Project* as the Design and Technology Coordinator. The key goal of the project was to support teachers in their standardisation and moderation processes and procedures by providing a wide range of student work that exemplified the attainment levels, 3-8. As the coordinator, I was responsible for gathering and collating the information to populate the web-based resource with Key Stage 3 examples of teaching and learning from students aged 11-14 years, that is, I was responsible for gathering work that would demonstrate learning in Design and Technology. It soon became apparent that demonstrating or even identifying and describing learning and learning progresssion in Design and Technology was not as straightforward process.
As the project progressed the key questions that emerged was: 'What does Design and Technology learning actually look like? and 'what planning approaches can be used to ensure the complexities of the subject are effectively demonstrated' Such fundamental questions have significant implications on the teaching-learning process and, in particular, how teachers identify the learning they want their students to achieve and subsequently plan learning opportunities to allow students the opportunity to demonstrate such learning.

Learning and learning outcomes

Learning presents a complex subject for enquiry involving a wide variety of interrelated and integrated factors, created through constant negotiations between individuals, social environments and broader social influences, thus infused with the complexity of learners' lives. Defining learning is particularly difficult and there are various ways of conceptualising it (Hager and Hodkinson, 2009), as a consequence there are a wide range of definitions available. Although there is no single external, reified entity that is 'learning', people construct and may regard certain processes/products/activities as such (SaljÖ, 2000). As Illeris (2007) suggests, there are three different meanings of the term 'learning' in everyday speech. Learning can refer to the outcomes of learning, i.e. what has been learnt, the mental processes used by individuals while learning, or the interactions between individuals and their environment, suggesting that learning can either be viewed as a 'product', a 'process' or a 'social activity' (Illeris, 2007: 3).

In England, secondary schools, with particular reference to Key Stage 3 students (aged 11-14 years old), 'a learning outcome sets out what a learner is expected to know, understand and be able to do as the result of a process of learning' , thus, it is a predictive statement of learning intention generally written by the teacher. As such, learning outcomes and intended learning statements are directly related. Generally, advice follows Kelly (2013) who contends that, for intended learning statements to be complete and effective, they must include two elements: they must define what is going to be learnt and, secondly, they must give an indication of how that learning will be assessed by stating the form of the learning outcome, that is determining the actual product, process or outcome (Eisner, 2002). The formulation of an intended learning statement generally takes place in the 'pre active' phase of the teaching-learning process and is generally based upon the pedagogical framework set out in the English National Curriculum.

Classroom-based learning

Classroom-based learning, often termed 'formal learning' or 'school-based learning', can be described as learning that involves and is generated by a teacher-student relationship in a classroom environment (Bell and Dale, 1999). In 'formal' learning environments, the teacher or department sets the goals and objectives, whereas generally 'informal' learning requires the learner to set their own goals and objectives (Cofer, 2000). Winch (1998) argues there are many and diverse cases of learning, each subject to constraints in a variety of contexts. It is, therefore, useful and more appropriate to consider learning as a continuum (Eraut, 2000). Figure 1.1 represents a 'continuum of learning'.

Classroom-based learning is associated with a narrow range of learning, often juxtaposed with 'informal' learning and involving aspects of learning considered important in secondary education (James, 2005). Classroom-based learning in school is dominated by the acquisition of knowledge and skills (Eraut, 2000; Pring, 2000; Illeris, 2003; James, 2008; Swaffield, 2009), traditionally the mainstays of the English education system (Perkins, 1993).

The dominant model of planning for learning

Rationalistic, technical curriculum planning has been the dominant model underpinning planning for teaching and learning for a generation or more in England and Wales (Parkay and Hass, 2000) and involves the use of a linear approach to planning, which begins with the specification of objectives and ends with a lesson evaluation. With reference to students' aged 11-14, the Key Stage 3 National Strategy for Design and Technology (DfES, 2004b), for instance, suggests the following format as a framework for planning: objective; vocabulary; resources; starter; main activity; and plenary. This dominant or 'rational' approach to planning is based on Tyler's (1949) model of curriculum theory and practice, comprising a systematic approach based upon the formulation of behavioural objectives, thus providing a clear notion of

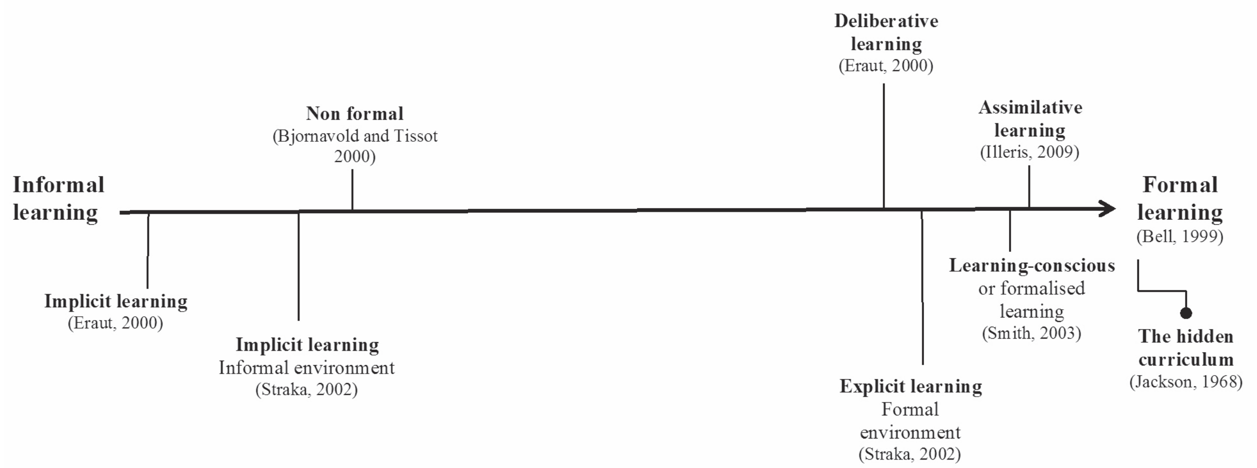

Figure 1.1 a 'continuum of learning'

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outcome, so that content and method may be organised and the results evaluated. It considers education to be a technical exercise of organising the outcomes or products of learning, whereby objectives are set, a plan drawn up and applied and the outcomes (products) measured. Snape (2013) provides an example of what he defines as 'quality learning' through such a technical, sequenced linear pathway, including: the intended learning; teaching episodes; opportunities for tangibly evidenced student work; and criteria for successful achievement.

In order to make progress at school, students are expected to deepen and broaden their knowledge and skill base. In regards to classroom-based learning, the teacher is responsible for controlling and managing the learning, albeit within a set pedagogical framework, through formulating the learning intention and identifying the learning outcome. James (2005) argues that one of the key virtues of focusing on knowledge and skills is the relationship to learning outcomes. Learning that involves developing knowledge and/or skills provides 'easily measurable' learning outcomes in the form of either written texts in relation to knowing, or performances in relation to acquiring skills (Moreland and Jones, 2000).

As well as being required 'to know' and 'to be able to', the requirement 'to understand' has developed as an important aspect of classroom-based learning and is often described as the application of knowledge and skills (CUREE, 2012). 'Understanding' is an abstract concept that is challenging to define and difficult to study from a scientific perspective (Bransford, Brown and Cocking, 2000). Nickerson (1985: 217) described understanding as an 'active process' that requires connecting facts or relating new information to what is already known into an integral and cohesive whole, such that understanding is seen to require having knowledge and then doing something with it. However, learning or learning outcomes based around understanding are difficult to plan for, teach, and, most noticeably, identify and assess by a teacher. Understanding is often neither visible (Hallgarten, 2014) nor immediate (Nuthall, 2011) and can often be transient and therefore the process of demonstrating, capturing, gathering and measuring learning, is potentially challenging. Bransford, Browning and Cocking (2000) argue that, although understanding is considered a necessary element of curricula, the focus on content and the memorisation of content knowledge is often over-emphasised in modern curricula, presumably due to the challenges related to developing 'understanding'.

Blythe and Perkins (1998: 12) developed a definition of understanding from a performance perspective, explaining that 'understanding' is a matter of 'being able to do a variety of thought-provoking things with a topic, such as explaining, finding evidence in examples, generalising, applying, making analogies, and representing the topic in new ways'. The advantage of performance is that the learning outcomes are generally visible (Kimbell, 2003). Whilst understanding demonstrated through performances may support the production of accessible learning outcomes, restricting the form through which learning relating to understanding is demonstrated limits the planning processes and ultimately restricts the teaching-learning process further.

Alternative models of planning

Several alternative and adapted planning approaches are present in the current literature, which are particularly pertinent to Design and Technology education. The 'naturalistic' or 'organic' model, based on the work of Stenhouse (1975) and Egan (1992; 1997), was developed from the apparent conflict between the need to carefully specify learning intentions and the dynamic nature of classrooms, and was an attempt to emulate a realistic planning process based on the 'natural' interactions in a classroom. Naturalistic planning involves starting with activities and the ideas that flow from them before assigning learning objectives (John, 2006). Although lacking detail in terms of pedagogical requirements and consideration, this model does resonate with Perkins, Tishman, Ritchart, Donis and Andrade's (2000) notion of 'learning in the wild', when learning settings are recognised as 'messy and complex' (Carr, 2008: 36). Perkins and Saloman (1992) argue for the need for learners to experience more 'natural' learning environments, with teachers' planning procedures supporting this notion.

Within a Design and Technology context, 'wicked problems or tasks' (Rittel and Webber, 1973) described as 'problems of deciding what is better when the situation is ambiguous at best' (Marback, 2009: 399), support the 'naturalistic' model, as wicked problems are not solvable; they are contingent problems of deciding what to do that require continual evolution and, as such, are based upon the continual morphing of ideas and idea development, through a problem- solving process (Kimbell, Saxton and Miller, 2000). Such a 'naturalistic' model requires teachers to plan and create realistic design scenarios in order for students to learn the authentic nature of design activity, thus allowing students to experience environments where experimentation and exploration are dominant approaches.

The 'interactional method' of planning, another alternative to the dominant model, stresses the interactive nature of learning and, therefore, learning objectives (Brady, 1995; Bell and Lofoe,1998). Whilst the 'interaction' model specifies the same design elements as the linear objectives model the 'interactional method' planning process can begin with any of the elements. Based on this model, all curriculum elements interact with each other during the design/planning process and, therefore, the design of one element will influence and possibly change the design decisions for other elements. For example, method might be specified first, but altered later as a result of an assessment decision. From a practical perspective, this model makes it possible to specify learning objectives after all other elements have been decided (Bell and Lefoe, 1998).

The 'articulated curriculum' (Hussey and Smith, 2003: 360) provides a similar approach to the 'interactional model', where the respective elements exist in a state of mutual interaction and influence. Alexander (2000) compares this 'articulated curriculum' approach to planning to the structure of a musical performance, where the composition is analogous to the lesson plan, and the performance shifts according to interpretation and improvisation. This 'responsive' approach to planning requires the teacher to be vigilant of the learning progression within the class and respond accordingly, and is synonymous with the formative assessment principles of 'feedback' (Ramaprasad, 1983). Biggs (1999) notion of constructive alignment also supports this way of approaching planning for teaching and learning.

Design and Technology education in England

In relation to the English education system, the Design and Technology National Curriculum Programmes of Study for Key Stage 3 (students' aged 11-14 years) sets out the knowledge, skills and understanding needed to progress learning in the subject. Arguably, the 2014 revised curriculum is a reaction to the recent focus on how children learn as opposed to what they learn, which had been firmly on the education agenda for several years (Lambert, 2007). However the explicit focus has shifted and is now upon the 'product of learning' and not the processes involved in learning; in this sense, it is 'learning-output' focused. However, the concept of 'process-driven task-centered learning' is driven by an associated 'process' rather than 'content' based pedagogical framework. Although the development of a proactive, process-centered view of Design and Technology has been seen in other areas of the curriculum, for example process science and process mathematics, the processes associated with Design and Technology learning not only distinguished it from other subjects (Davies, 2000), but helped define the discipline (Kimbell, Stables and Green, 1996; Wilson and Harris, 2004). The 'unique' nature of Design and Technology, in terms of developing capability to operate effectively and creatively in the made world, is frequently conceptualised within the current literature (see Holdsworth and Conway, 1999; Middleton, 2005; Kimbell, 2006; Green and Steers, 2006; Barlex and Welch, 2007) and the process-based nature is a common justification of this 'uniqueness'.

A focus on the application of 'knowledge' has always been present in Design and Technology learning and the 'active' use of knowledge and skills is evident in the various 'thinking-centered processes' such as designing, evaluating skills and problem solving associated with the subject. These cognitive processes often involve 'tacit' knowledge, that is, 'a range of conceptual and sensory information and images that can be brought to bear in an attempt to make sense of something' (Hodkin, 1991: 256). Introduced by Michael Polanyi in 1967, 'tacit' knowledge refers to a 'pre-logical phase of knowing' (Polanyi, 1967: 4) and is described as the informed guesses or hunches that are part of an exploratory act, motivated by what Polanyi describes as 'passions'. 'Tacit' knowledge is inherently personal, and requires pedagogical methods and strategies that reveal the processes associated with such knowledge.

Such cognitive or metacognitive skills associated with this type of learning are not only difficult to plan for, but problematic to capture and gather and thus do not easily provide learning outcomes. Consequently such types of learning are often overlooked by Design and Technology teachers (Kimbell, 2003; Richardson, 2010), resulting in further limiting the range of types of learning provided by teachers and produced by students.

Aspects of learning associated with Design and Technology

The learning associated with Design and Technology is complex; the various material-focus areas, the designing and making aspects, and contextual needs require learning to be considered as both multimodal and multidimensional. The relationship between the different aspects of learning, namely knowledge, skill, understanding and process, is complex in all subjects, but no more so than in relation to Design and Technology teaching and learning. Planning to ensure different aspects of the subject are developed and then demonstrated is far from easy.

What Does Design and Technology Learning Really Look Like?

In 1949, Ryle argued that knowledge could be divided into 'knowing that' and 'knowing how' (Ryle, 1949). Often used to describe the categories of propositional or declarative knowledge and procedural knowledge, these forms exist in order to 'learn about' and 'learn to' outcomes in Design and Technology classrooms (Goodwin, 2013), providing learning outcomes that can be planned for, taught, learnt and assessed (James, 2008). However, Kimbell (2005) contends that Design and Technology learning is more than just 'knowing that' or 'knowing how' and is often associated with a different type of knowledge, 'knowing why'. 'Knowing why' extends either the proficiency in a skill or the accumulation of knowledge (Baynes, 2010) and is fundamental to problem-solving and product development. 'Knowing why' forms the basis of design decisions and justifications throughout the process of Design and Technology and is a crucial aspect of Design and Technology (Kimbell, 2005). Research findings highlight that this form of knowledge is often neglected in terms of learning outcomes in Design and Technology (Southall, 2015).

Issues are compounded when you consider that the nature of Design and Technology activity requires knowledge, skills and understanding on a 'need-to-know' basis (Kimbell et al., 1991) and are difficult to plan for. Gershenfeld (2005) termed this type of knowledge, '*Just in Time*' learning as opposed to, '*Just in Case*' learning. Professional practice in design allows the task or brief to dictate both the most appropriate processes required and the necessary knowledge and skills needed to progress to an effective solution. Key Stage 3 *classroom-based learning* requires the teacher and the learning environment to support, through careful planning, the development of the essential knowledge, skills, understanding and processes, as students or novice designers (Welch, 2000) do not have a wide range of previous knowledge or skills. The task context provides guidance on the right depth and the right form of knowledge (Atkinson, 2013). With truly opened-ended context-dependent designing and making, the knowledge used is specific to that particular situation. At Key Stage 3, the teacher supports the learning by providing the teaching opportunities needed for the required activity, thus balancing the level of prescription in order to achieve learning progress. At Key Stages 4 and 5, the student is increasingly expected to identify and gather the required knowledge, skills and understanding relative to the context (Nicholl and McLellan, 2009).

Such an approach, which develops knowledge and skills on a 'need-to-know' basis, places an emphasis on teaching students a process that involves identifying how and when knowledge is required, and not on the knowledge students may one day need (Owen-Jackson and Steeg, 2007). Unlike other subject disciplines, this '*Just in Time*' learning makes the defining of any specific knowledge boundary difficult (Martin, 2011), while creating a subject that is unique both in terms of teaching and learning (Middleton, 2008; Barlex and Pitt, 2000; Kimbell, 1997). This emphasis requires a clear view of the role of knowledge in Design and Technology teaching and learning and has implications for the planning, as well as the acquisition of knowledge, through suitable learning activities.

Design and Technology teaching approaches

Designing and design development is often described as a holistic process (Banks, 1996; Owen-Jackson, 2002), one which requires the student to be mindful of the 'bigger picture' irrespective of the particular phase or stage they are currently focusing on. Given this, as Kimbell and Miller argue, 'designers need to keep the task at the forefront of their thinking and continually revisit it, refining and redefining their understanding of it and consequently their design proposals to meet it' (Kimbell and Miller, 2000: 123). As with any atomisation process, be it atomisation of knowledge, skills or process, the separation into distinct or smaller units creates confusion in regard to the inevitable interaction of those units (Kimbell, 1997). Both 'assimilative' and behaviourist learning processes involve 'atomisation' of knowledge or skills into distinct or smaller units of knowledge/learning and both can be criticised for isolating learning. Sadler (2007: 6) explains that, the more a process is atomised, 'the harder it is to make the bits work together as a coherent learning experience' and the 'whole' is often neglected. Moreland and Jones' (2000) research into teacher knowledge and Design and Technology education and highlight 'atomising' as a common issue with current assessment procedures, concluding that, 'although tasks are meant to be reflective of technology, they appear to be somewhat isolated experiences, rather than cumulative and purposeful' (Moreland and Jones, 2000: 230). In this regard, there is compelling evidence that teachers need to identify and plan for specific and overall Design and Technology outcomes rather than just activities (Jones and Moreland, 2005; Moreland et al., 2008).

An 'integrated approach' to Design and Technology is clearly represented in the Assessment of Performance Unit's (APU) (Kelly, A.V., Kimbell, R., Patterson, V. J., Saxton, J. and Stables, K., 1987) model of 'interaction between mind and hand', which focuses upon the thinking and decision-making processes involved in 'designing and making'. The APU model rejected the dominant linear model of the design process instead promoting a view of activity that took the development of a speculative or 'hazy' initial idea to the point of becoming an effective working reality through an iterative process of thought and action. The 'integrated approach' to Design and Technology has a significant influence on the choice of teaching strategy, the learning opportunities and the learning outcomes and aligns with a constructivist approach, namely facilitation of learning, learner-centeredness, active and participative learning, creative and critical thinking and problem solving (Reddy et al., 2003). However, the APU model raised several issues in relation to assessment, not least the fact that some see the 'thinking and decision-making processes' inherent in the approach to be both invisible and, thus, often inaccessible (Kimbell, 2003). The APU model was never thoroughly embraced by the teaching community due to a lack of clarity regarding the form of learning outcomes and the absence of a practical assessment framework (Fox-Turnbull and Snape, 2011).

Several models have been proposed that attempt to reveal the cognitive aspects of the subject. Project e-scape (Kimbell, 2006, 2008) provides an innovative way of accessing 'design thinking' and 'cognitive thinking processes' were by the learner's portfolio is used as a device to 'underpin the learner's metacognitive growth throughout the Design and Technology process' (Kimbell and Stables, 2007: 217). Hope (2009) describes the process as a cognitive journey. Similarly, Barlex's (2008) *minimally invasive* approach to assessing Design and Technology learning also relies on revealing 'design decision-making', which Barlex believes lies at the heart of Design and Technology education. Opportunities for students to reflect on, and reveal, their progress in making design decisions as the task progresses would be planned into the project; therefore, as Barlex argues, 'essentially the assessment exercise has to probe and record chronologically the pupil's thinking' (Barlex, 2008: 53). Arguably, the *minimally invasive* approach removes the focus from the various stages of the design process and places it firmly on the student's personal learning journey. Barlex argues the process of designing needs to provide evidence of learning, a natural by-product of the learning, captured and gathered in an unobtrusive a way as possible, in order to retain their validity and reliability. Both approaches to assessing an 'integrated approach' to Design and Technology would provide distinctly different learning outcomes when compared to the dominant design process model.

Categories of learning	Number of learning outcomes (*n=33*)
(1) **Attainment**: often based on the school curriculum or on measures of basic competence in the workplace	13 39%
(2) **Understanding**: of ideas, concepts and processes	2 6%
(3) **Cognitive and creative**: imaginative construction of meaning, arts or performance	5 15%
(4) **Using**: how to practice, manipulate, behave, engage in processes or systems	19 57%
(5) **Higher-order learning**: advanced thinking, reasoning, and metacognition	0
(6) **Dispositions**: attitudes, perceptions, motivations	0
(7) **Membership**: inclusion, self-worth: affinity towards or readiness to contribute to the group where learning takes place	0

Figure 1.2 Design and Technology intended learning statements classified into learning categories
(learning categories taken from James and Brown, 2005: 10-11)

The concept of a learning outcome

Current educational practice surrounding the concept of a learning outcome is dependent upon the rather simplistic notion that learning outcomes can demonstrate learning (Swaffield, 2009); furthermore, that learning outcomes can demonstrate the range of learning set out in the National Curriculum. Although the process of formulating learning into statements that involve indication of the learning outcome, appears to be relatively simple, it relies on two key aspects. Firstly, the teacher understands the complexities involved in learning and particularly, Design and Technology learning and secondly, the concept of learning can be demonstrated through learning outcomes.

Design and Technology learning outcomes

Learning outcomes are intended to provide the evidence of learning progress, a key indicator of successful teaching (Ofsted, 2014), which can then be used for either summative or formative purposes. Research into the nature, scope, or type

Form of learning outcome gathered	Example	%
Practical	Physical products made by the students	46
'Sketched' or 'drawn'	Initial ideas Working drawings	15
Written	Evaluations Product analysis	39

Figure 1.3. Methods used to gather learning outcomes

of Design and Technology learning outcomes has been seriously neglected, and in particular how practical outcomes contribute to the theoretical perspective associated with Design and Technology. In practice, the learning outcomes commonly associated with Design and Technology learning tend to involve aspects of either 'designing' or 'making, having either a written, sketched or drawn, or 3D/*realised* form'. Findings from this research project support this contention; learning outcomes were associated with either 'designing' or 'making' activities or a stage of the design process (see figure 1.2 below). There was no evidence of learning outcomes that attempted to demonstrate 'higher-order' learning.

The methods used to gather the learning took one of three forms, the results of which are presented in Figure 1.3. The results indicated that the typical method of gathering learning was either through practical outcomes and products or through worksheet-based activities.

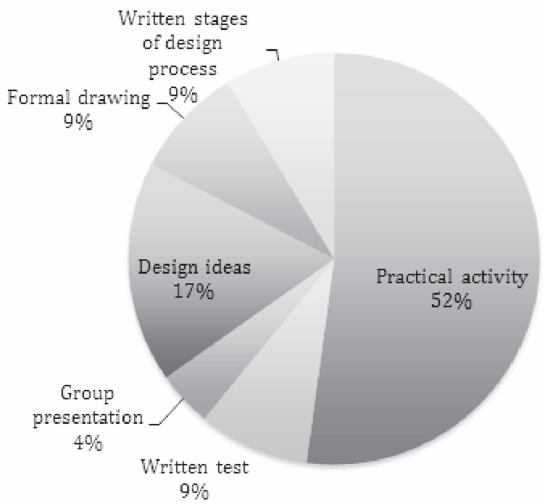

Figure 1.4 Methods used to capture the learning outcomes

Methods used to capture learning are presented in Figure 1.4, which shows the 'tangible' learning outcomes identified by the teachers in the lesson plans. Practical outcomes were considered the most appropriate method and support the dominance of practical activities used in Design and Technology learning journeys. It is interesting to note that written tests were considered suitable methods of capturing learning in 9% of the 47 lesson plans analysed.

It can be argued that, in order for students to refine their learning outcomes and determine appropriate assessment criteria, 'deeper cognitive, metacognitive and self-regulatory resources must be brought to bear in a deliberate and focused manner' (Zimmerman, 2008: 23). By placing the focus on the individual 'cognitive journey', students – and not teachers – develop the declarative, procedural, and contextual knowledge required in Design and Technology learning. This raises questions about the type of knowledge that is missing from the school curriculum and, consequently, the forms of knowledge from teaching and learning experiences in the Design and Technology classrooms. Self-regulated expert students possess conditional, strategic and metacognitive forms of knowledge in order that they can solve problems in authentic contexts (Paris, 2001). Yet, as Goodwin (2013) argues, Design and Technology rarely acknowledge and/or nurture the development of these forms of knowledge. By ignoring certain knowledge forms or by focusing only on a specific sub-set of knowledge within a general category, e.g. procedural knowledge, the processes that are necessary to develop flexible and adaptable thinking are greatly constrained and devalued (Goodwin, 2013).

Conclusion and recommendations

The processes involved in Design and Technology activities, requisite procedural knowledge, practical skills, thinking skills and creative skills establish a complex inter-relationship between conceptual/content knowledge and procedural knowledge (Reddy, Ankiewicz, Swardt and Gross, 2003). The teacher is required to establish a balance between methods that effectively deliver content and develop skills (Owen-Jackson, 2013), allowing students to develop and use both content knowledge and procedural knowledge, consequently learning outcomes need to focus upon and demonstrate this inter-relationship. As Moreland, Jones and Barlex (2008) argue it is through the application of knowledge, skill and understanding that students' ability in Design and Technology is actually revealed and as such, this interplay is the point where learning can be demonstrated, captured and gathered.

This article has highlighted some of the issues involved in planning and subsequently identifying learning in Design and Technology. The use of the dominant model of planning needs to be questioned and alternatives approaches to planning developed that support the teaching and learning in Design and Technology education. Various models exist that could be modified to support the planning process, emphasising and/or reinforcing certain aspects or concepts of the subject and potentially providing the focus for a variety of planning processes. Morgan, Jones and Barlex's (2013: 4) approach involves the notion of 'a Design and Technology Toolbox'. This approach splits Design and Technology into four groups: design, technology, critique and data. A series of key concepts and principles is associated with each group and aims to provide a coherent curriculum for Design and Technology, which involves an integrated understanding of the key concepts across all material areas. Barlex and Rutland (2004) introduced the 'design decisions pentagon', a conceptual model designed to develop insights into the requirements of teaching designing. The model involved five conceptual considerations: conceptual; marketing; technical; constructional; and aesthetic (Rutland, 2009; Barlex and Rutland, 2004). Moreland's (2008) primary planning tool focused specifically on the multidimensionality of Design and Technology, providing teachers with the opportunity to consider conceptual learning outcomes, procedural learning outcomes, societal learning outcomes and technical learning outcomes during the planning process. By providing or developing alternative teaching and learning frameworks for Design and Technology pedagogy, teachers are provided with a range of approaches to planning processes that may be better suited or supportive of the intended learning experience.

In order to develop the skills, knowledge and understanding associated with Design and Technology 'teacher-dominated' outcomes of learning cannot be the standard approach (Nicholl and McLellan, 2009). Although beneficial in relation to skills acquisition and providing evidence of learning progress, 'teacher-dominated' learning outcomes tend to neglect deep learning experiences, whilst promoting replication of knowledge and skills through a procedural approach. Progression through Key Stage 3 needs to provide a variety of teaching-learning opportunities, ranging from 'teacher-controlled' units to 'mix authority' teaching to 'student-led' activities. In response to the design brief or problem, the degree of freedom given to the students is inversely proportional to the control of the variables, such as materials and time, by the teacher. 'Student-led' or 'student-managed' activities need to be based upon authentic tasks, collaboration and the processes involved in designing and making. Both the *iterative* and *user-centred* design approaches, if employed effectively, produce solutions that are neither predetermined nor foreseen. Both models require design development to be based upon 'authentic' feedback, either from prototyping and modelling or from user testing; consequently, both approaches can be described as 'designer-led' or, indeed, 'student-led' activities. Student ownership of learning outcomes would help address the narrow band of learning outcomes that currently exist in classrooms, improve creativity, reduce issues with validity and learning outcomes and provide authentic responses to *intended* learning statements.

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